Exploring Talent Development Pathways in the Construction Industry Amid Digital Transformation

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Abstract. This study aims to explore effective talent cultivation paths in the construction industry under the context of digital transformation. With the rapid development of technology, digital transformation has become a significant trend in the construction industry, leading to substantial changes in talent demands. This research starts from the context of digital transformation, deeply analyzes the current state of talent in the construction industry, and proposes corresponding analyses of talent cultivation needs. To address this challenge, this paper presents suggestions for optimizing curriculum settings and updates, emphasizes the importance of practical teaching and training, and explores the value of interdisciplinary cooperation and communication in talent cultivation. Additionally, the study highlights the necessity of corporate participation and school-enterprise cooperation to enhance the practicality and specificity of talent training. Overall, this research provides a comprehensive analysis of talent cultivation paths in the construction industry under digital transformation, aiming to cultivate high-quality talents who meet the needs of digital transformation, thereby promoting the industry's sustainable development.

Keywords: Digital Transformation; Construction Industry; Talent Cultivation

1 INTRODUCTION

As technology rapidly advances and the wave of digitalization progresses, the construction industry faces unprecedented transformations. Traditional talent cultivation models in the construction industry, which often focus on theoretical learning and basic skills mastery, are no longer sufficient to meet the industry's evolving needs. Digital transformation requires not only solid professional knowledge and basic skills but also innovative thinking, cross-disciplinary integration capabilities, and a habit of continuous learning[1]. Therefore, researching and exploring new paths for talent cultivation in the construction industry under digital transformation is crucial for the industry's sustainable development as shown in Figure 1.

M. S. H. Talpur et al. (eds.), *Proceedings of the 2024 4th International Conference on Internet Technology and Educational Informatization (ITEI 2024)*, Atlantis Highlights in Social Sciences, Education and Humanities 27,
https://doi.org/10.2991/978-94-6463-560-7_4

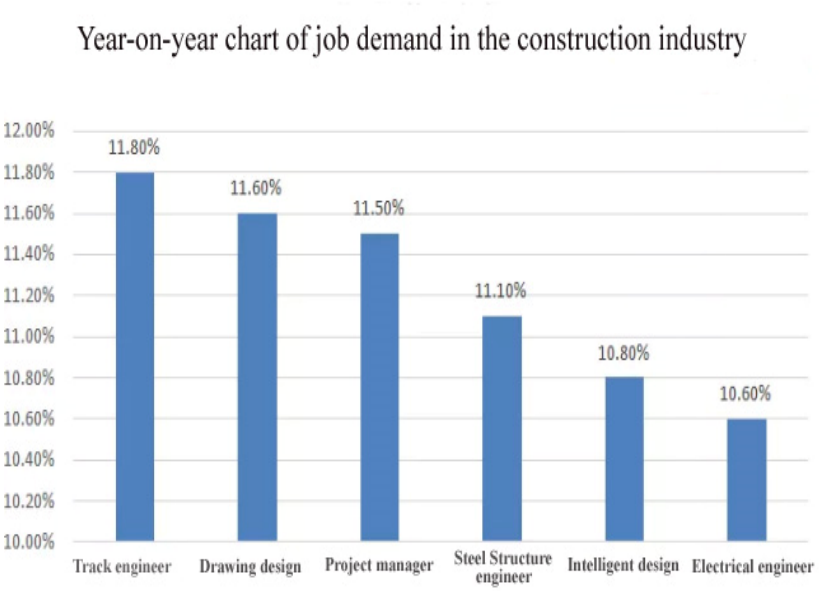

Fig. 1. Demand Graph for Positions in the Construction Industry

2 THE IMPORTANCE AND URGENCY OF TALENT CULTIVATION

Driven by digital transformation, the construction industry's technology update speed is increasing rapidly. New technologies, processes, and equipment continuously emerge, requiring professionals to continually learn and master new knowledge and skills. Thus, cultivating talents with the ability to continuously learn is crucial for adapting to technological changes and maintaining industry competitiveness. However, with the widespread application of digital technologies, there has been an explosive growth in demand for talents with digital skills, yet the market currently faces a significant gap in available professionals with the necessary knowledge and skills. In addition to traditional construction roles, the demand for emerging construction positions is also rising. Specific positions such as track engineers, construction drawing designers, project managers, steel structure engineers, smart design specialists, and electrical engineers have seen significant increases in recruitment demands, with year-over-year growth rates of 11.8%, 11.6%, 11.5%, 11.1%, 10.8%, and 10.6%, respectively. The recruitment demands are particularly high in regions like Guangdong, Jiangsu, Zhejiang, and Sichuan due to the commencement of construction projects and new infrastructure projects, with year-over-year growth rates of 11.5%, 11.3%, 11%, and 10.9%, respectively. Therefore, strengthening the cultivation of digital talents has become an urgent issue for the industry[2].

3 ANALYSIS OF TALENT CONDITIONS IN THE CONSTRUCTION INDUSTRY

3.1 Talent Structure and Demand Gap

The current talent situation in the construction industry is facing several challenges, the most prominent being the gap between the existing talent structure and industry demands. Below is an analysis of the current talent conditions in the construction industry, as shown in Figure 2 with a focus on the talent structure and demand gap:

Current Talent Structure.

a) Educational Background and Professional Skills: Although there is an increasing demand for highly educated and skilled professionals in the construction industry, there still exists a significant proportion of the workforce with lower educational levels and non-specialized skills. This limits the overall technical level and innovation capabilities of the industry.
b) Age Structure: Currently, the age structure of the workforce in the construction industry is skewed towards older employees, with relatively fewer young talents. This may result in a lack of sufficient drive for innovation and development within the industry.
c) Geographical Distribution: There is an uneven distribution of talent geographically, with a concentration of skilled workers in large cities and developed areas, while smaller cities and less developed regions have fewer construction professionals. This limits the development potential of the construction industry in these areas as shown in Table 1.

Table 1. Distribution of digital talents in cities

Digital management talents	Digital application talents	Digital professional talents
Beijing: 25%	Beijing: 31%	Beijing：23%
Shanghai: 11%	Shanghai：11%	Shanghai：9%
Shenzhen: 11%	Shenzhen：6%	Shenzhen：8%
Guangzhou: 5%	Hangzhou：6%	Hangzhou：5%
Hangzhou: 4%	Guangzhou：4%	Guangzhou：4%
Chengdu: 3%	Chengdu：3%	Chengdu：3%
Nanjing: 2%	Nanjing：2%	Nanjing：3%
Suzhou:2%	Wuhan：2%	Xi'an：2%
Wuhan:2%	Chongqing：2%	Wuhan：2%
Xi'an:2%	Tianjin：2%	Suzhou：2%

Source: Maimai Data Research Institute

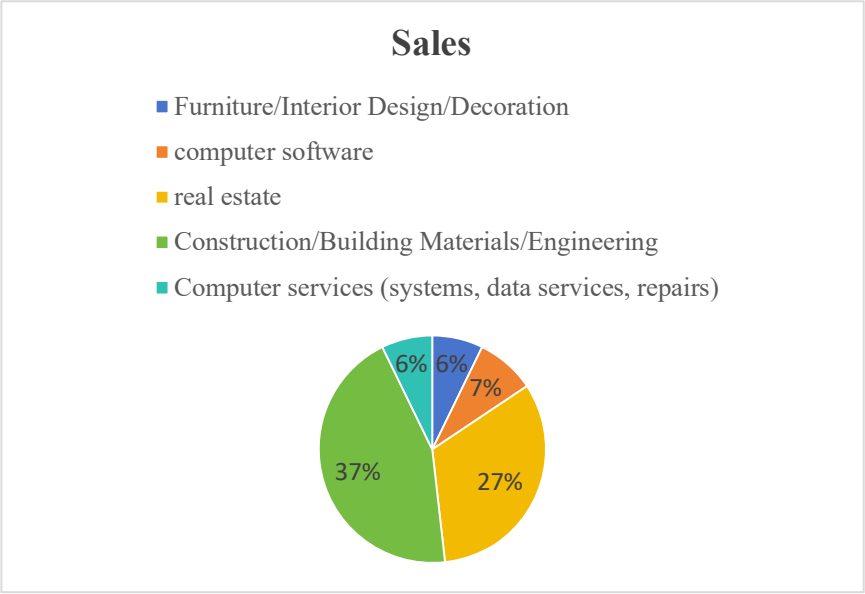

Fig. 2. Employment industry distribution of undergraduate graduates majoring in architecture (unit: %)

Demand Gap for Talent.

a) Shortage of High-end Talent: As the construction industry evolves towards high-end and intelligent directions, there is an increasing demand for talents with international perspectives, innovative capabilities, and interdisciplinary backgrounds. However, such talents are currently scarce in the industry, making it difficult to meet the demands of rapid development.

b) Increased Demand for Composite Talents: The construction industry is gradually integrating with information technology and intelligent solutions, leading to a growing need for talents who are knowledgeable in both construction and information technology. However, such composite talents are relatively rare in the industry.

c) Shortage of Grassroots Skill Talents: Despite the increasing demand for high-level talents, the shortage of skilled grassroots workers cannot be overlooked. Many construction projects are delayed or fail to meet quality standards due to the lack of skilled grassroots workers. According to statistics checked by Baidu, currently 37% of my country's undergraduate graduates majoring in architecture are employed in the construction/building materials/engineering industry, 27% are employed in the real estate industry, and 7% are in the computer software industry.

3.2 Matching Professional Skills with Digital Capabilities

During the digital transformation process, the construction industry's demand for talent has undergone significant changes. It is essential for professionals to possess not only traditional skills but also digital technologies such as BIM (Building Information Modeling), cloud computing, big data, and artificial intelligence. These digital technologies enhance the efficiency and precision of architectural design, construction, and management, playing a crucial role in modernizing, intellectualizing, and greening the construction industry. However, there are some issues with the alignment between professional skills and digital capabilities in the current construction sector. On one hand, many traditional construction practitioners, despite having extensive practical experience and professional skills, have a low mastery of digital technologies, making it difficult for them to adapt to the needs of digital transformation. On the other hand, some younger construction practitioners, although familiar with digital technologies, lack practical engineering project experience and professional skills, making it challenging for them to fully perform in the construction industry.

4 TALENT CULTIVATION STRATEGIES IN THE CONTEXT OF DIGITAL TRANSFORMATION OF THE CONSTRUCTION INDUSTRY

With the digital transformation of China's construction industry, construction-related universities in China should seize the development opportunity, transform traditional concepts, optimize talent training programs, and reconstruct curriculum systems. Specifically, they can start from revising training programs, innovating teaching methods, promoting "industry-academia-research-application" collaborative training, and establishing a "three-in-one" innovative talent training model for the construction industry, as shown in Figure 3.

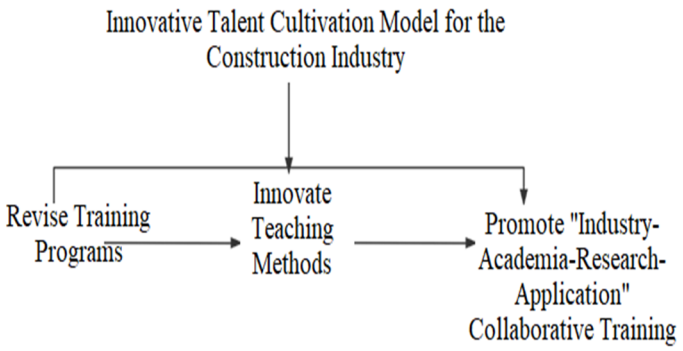

Fig. 3. Innovative talent training model for construction majors

4.1 Revise Training Programs

Generally speaking, training programs consist of knowledge training, capability training and quality training. Therefore, the training plan for innovative talents in the construction industry can be broken down into knowledge modules, capability modules and quality modules, each containing the next layer of structure, as shown in Figure 4. In this context, the reform of China's innovative talent training program for the construction industry should start from the following three aspects[3].

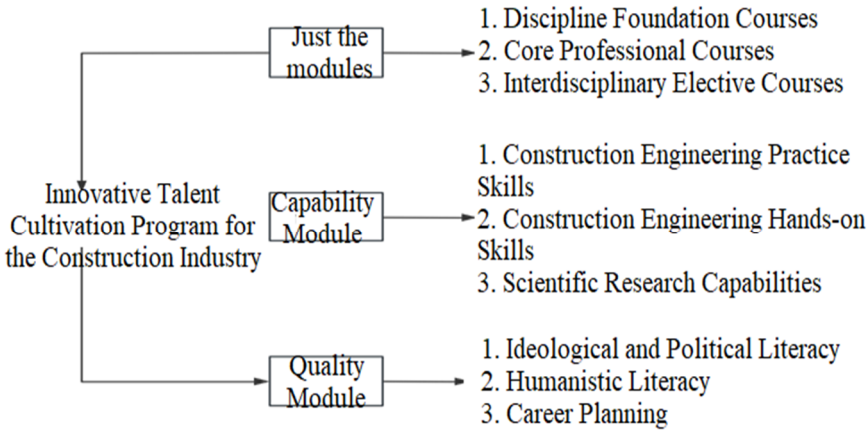

Fig. 4. Innovative deconstruction of talent training programs in the construction industry

Knowledge Module Content. First of all, practitioners in the construction industry need to master a solid professional basic knowledge, including architectural design principles, structural mechanics, materials science, etc. These basic knowledge is the basis for subsequent learning and application of new technologies, and also the cornerstone for practitioners to innovate and solve complex problems.

In the process of digital transformation, the application of data analysis and computer methods are becoming increasingly important. Construction industry practitioners need to master certain knowledge of data analysis and computer programming to be able to process and analyze a large amount of data in construction projects, extract valuable information, optimize the design scheme, and improve the construction efficiency. For example, data analysis techniques can be used to more accurately analyze the stress and performance of buildings, or computer methods can be used to optimize building materials.

The professional basic courses are divided into basic mathematics, computer basics and management basics. The class hours and difficulty of computer professional basic courses can be moderately increased. The core professional courses can be divided into three groups, offered in the third, fourth and fifth semesters according to the gradual learning process of knowledge, with the application of BIM software incorporated into

the curriculum settings. The first course can provide software learning on BIM structural modeling at the same time; the second course can offer research on engineering cost estimation and quantity software at the same time; the third course can provide learning courses on BIM integrated management software at the same time. This can organically combine the relevant content of BIM software and the content of professional courses, which improves students' ability to use BIM software while promoting continuous consolidation and application of the knowledge they have learned. In the fifth and sixth semesters, interdisciplinary elective courses can be offered across disciplines. The main research content of this project includes: artificial intelligence, Internet of Things, big data, cloud computing, mobile Internet, virtual reality, 3D printing, machine vision, robots, etc. A series of courses can be offered under specific topics for students to choose from. The curriculum settings need to reflect a step-by-step progression from basic principles to practical applications. The courses in this module should broaden and dig deeper to improve students' ability to apply knowledge in this field[4].

Capability Module Content. The capability module mainly consists of project hands-on skills, engineering practice skills and scientific research capabilities. As the construction industry is a very practical industry, universities should bring classrooms to laboratories, combine theories with practice, keep up with the digital transformation of the construction industry, and integrate theories with practice. In the practice process, attention should be paid to the organizational structure of the BIM software learning process, from 2D drawings to 3D, and then to specific projects (quantity takeoff, cost estimation, integrated management), while complementing classroom teaching. Elective courses can also be offered jointly with other disciplines and corresponding experiments conducted. At the same time, professional internship platforms can be established through cooperation with enterprises to cultivate students' hands-on and scientific research capabilities. For example, Chongqing University has jointly established training platforms with many enterprises such as China Construction, Guanglian Dache, Woods Bagot, and Far East, in areas including practical training, scientific research and innovation, comprehensive quality, talent recruitment, dual-teacher training, and has built a number of "smart construction" collaborative education bases for industry-academia-research, virtual simulation visualization technology teaching application bases, construction digital industry Internet innovation bases. Based on this, increasing the proportion of practice and research in talent training can meet the needs of digital construction and train innovative engineering management talents for China.

Quality Module Content. The quality module consists of ideological and political literacy, humanistic literacy, and career planning. The purpose of cultivating innovative talents in the construction industry is to nurture civil engineering leading talents with noble moral character, strong sense of social responsibility, good professional ethics, solid scientific foundation, outstanding humanities and social sciences quality, feelings for family and country, international perspective and innovative spirit. Graduates should be able to apply modern technologies such as information, networks, automa-

tion, big data and intelligent algorithms, be competent in digital design, automated construction and intelligent operation and maintenance, and engage in technology R&D, consulting and services, to become the backbone of technology and management in the new infrastructure and integrated infrastructure fields within five years[5].

4.2 Innovate Teaching Methods

Promote "case-driven" Teaching Method. The "case-driven method" refers to the guidance of actual work (case + case) while contacting key theories. Harvard Law School first introduced case teaching in 1870. Since then, authoritative institutions in the field of engineering management such as the Project Management Institute (PMI) and the International Project Management Association (IPMA) have attached great importance to case teaching for talent cultivation. At present, most courses in the field of university construction in China use PPT courseware, which has improved students' grasp of professional theories to some extent, but students learn fragmented theories and cannot fully understand and analyze the overall ideas of engineering projects. Considering that the construction industry is a very practical profession, combined with the current development trend of digital economy in the construction industry, universities need to change the traditional model of imparting theoretical knowledge and enable students to transform from "passive" to "active" through case teaching, so that students can gain knowledge in class and be able to choose their own engineering roles[6].

Implement the "dual-teacher" Teaching Model for Engineering. Universities in construction should strengthen cooperation with various participating parties and contractors, continuously optimize the faculty team, and vigorously promote "dual-teacher" education on this basis to integrate engineering construction theories with practice. In teaching, school teachers are responsible for lecturing on basic knowledge and supervising internships and graduation theses; in teaching, teachers should strengthen students' practical research and innovation capabilities, increase students' internship experience, reduce students' employment adaptability, enhance students' professional skills and entrepreneurial abilities. The "dual-teacher" system can establish a "win-win" relationship between schools and enterprises, but construction students under the "dual-teacher" system benefit the most. The "dual-teacher" system can effectively make up for the insufficient knowledge structure of teachers within the school and promote the talent training process.

Strengthen the Construction of On-campus and Off-campus Internship Training Bases. Judging from the current situation in the field of university construction, most development directions are related to construction technology and project management, and there is an urgent need to increase capital investment, improve the teaching environment, and actively promote the development of teaching software and hardware, internships, and practical training platforms. This will accelerate the construction of on-

campus and off-campus internship training bases in construction majors, improve the service level of theoretical teaching, practical teaching and quality teaching. By building internship and training bases, universities have abundant human resources, advantageous disciplines, characteristic majors, emerging scientific research results, and the latest massive scientific and technological information. This allows universities to fully, quickly and profoundly communicate with industry organizations; at the same time, in the process of production practice, talent utilization, product R&D, promotion and application, outstanding university graduates can be absorbed into corporate technological transformation and major project R&D, which can optimize R&D teams and achieve leapfrog development through interaction[7].

4.3 Promote "industry-academia-research-application" Collaborative Training

"Industry-academia-research-application" collaborative training refers to the cooperation between the government, enterprises, universities and research institutes, giving full play to their respective advantages, and having strong integration capabilities in top-level design, talent training, scientific research and industrial talent demand. The state's vigorous development of the digital economy and digital transformation of the construction industry, as well as the training of innovative engineering management talents, are all under the top-level design of national policies and standards. Project management is a very practical interdisciplinary subject. In the construction project process, many practical problems and difficulties need to be solved through solid basic theoretical knowledge and in-depth scientific research and practice. From the perspective of talents in the construction industry, schools should take the initiative to guide students to engage in engineering practice, scientific research and social practice, unify knowledge and practice, promptly understand the demand for engineering management talents from enterprises, research institutes and the government, and adjust teaching objectives and directions in a timely manner. In the 1990s, two professors, Henry Etzkowitz from New York University and Loet Leydesdorff from the Amsterdam Institute of Advanced Studies in Science, Technology and Modernization jointly proposed the "Triple Helix" theory, which breaks through the dual linear structure of "university-industry" and establishes a nonlinear networked innovation model of "university-industry-government", where the government, industry, and universities, each maintaining its independence, form three forces that influence each other in a spiral upward relationship of competitive cooperation[8].

5 CONCLUSION

In summary, researching and practicing the path of talent cultivation in the construction industry under digital transformation is of great significance. We should closely align with industry development trends and market demands, continually innovate talent cultivation models and methods, and cultivate high-quality talents with digital skills and

innovative consciousness to promote the sustainable development and transformational upgrading of the industry.

PROJECT INFORMATION:

Exploration of Innovative Talent Cultivation Paths in the Context of Vocational Education's Digital Transformation
Project Number: Hnjg2024ZD-81

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